The Science Teacher

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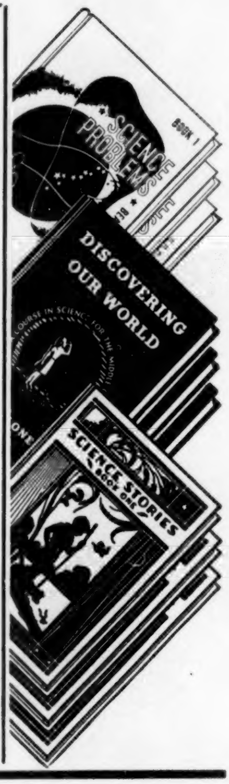

SCIENCE PROBLEMS
BOOK 1
DISCOVERING OUR WORLD
SCIENCE STORIES

The Science Teacher

VOLUME VI APRIL, 1939 NUMBER 2

The Scientific Method

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Recently, William Lyon Phelps delighted an audience here at the University with an address which was partly poetry and partly wit. One statement made at the beginning of his address with theatrical effect took his audience by the ears, delighting the humanists and startling the scientists. He said in part, "the truths of literature are truer than the truths of science. I can prove it in a sentence. If you buy a scientific book, be sure to get the latest edition," Of course, every one knows that in literature the oldest edition is the most valuable. Now, if one wished to enter into the spirit of clever repartee with Dr. Phelps, he would retort that the truest science was the law for there a judge lays down a precept and establishes a precedent that succeeding generations follow in the manner of the Medes and Persians. Or to take another illustration even more unfair, history repeats itself and historians repeat each other. "That's my story and I'll stick to it," is Dr. Phelps' criterion of truth when expressed in the vernacular.

But we plodding scientists have learned that if a thing is clever it probably isn't true and that "all generalizations are false including this one" as the Frenchmen said with unfaltering logic. And so it seems worth while this afternoon to take Dr. Phelps' statement apart and see what truth it contains. Let us proceed to do this in a humble spirit because nothing is more to be more shunned than scientific philistinism. The outstanding example of this for all time, I suppose, was the famous member of the Adams family, who himself president of the Union Pacific Railway Company, lamented that his life had been ruined by the veneer of classics imposed upon him by Harvard College; that he had learned nothing useful. I pray not to become a scientific philistine; I may fear the Greeks and still covet their gifts.

Dr. Phelps used as an illustration of the changeless truth of literature, the account of the siege of Troy written by a man whose alias was Homer and who was sought by seven cities, presumably not in a vindicative spirit. Dr. Phelps pointed out that the description of human nature, the admiration of the male sex for the perfidious Helen with the face that launched a thousand ships, the bravado and jealousness of the male warriors strutting like turkey cocks, the love of children and parents and all the emotions portrayed as on a gigantic canvas, are as apt a description of the human race (so-called) when engaged in its principal occupations of love and war, as though it were written today, and as a matter of fact, to be a little Irish, a great deal better. Now let us see how a scientist would analyze this statement.

The first thing he would say is that human nature doesn't change—very rapidly. Two or three thousand years elapse and we are little different. I almost said little better than the Greeks. The second thing is that the observation and description of the external be-

havior of human beings is an art- poets are born and not made, says the Latin quotation—and the competency of art is not handed down from one generation to another but must be acquired by an individual in the course of a lifetime. It is not surprising therefore that occasionally a man should have reached such stature as a poet, that his figure looms across the centuries like a distant mountain peak towering above the nearer foothills. Superficially, human moods, vagaries, and passions are still the same. The description still fits.

But what kind of truth is it that Iliad gives us and how far does it penetrate? What does a description of human nature and personality amount to? Does anyone really know anyone else's personality, let alone being able to set it down in cold type? A behavioristic description of personality is very superficial description. To the scientist, personality is largely glands and while no scientist would attempt to write a chemical formula for personality, he suspects that no exact description can be given without the use of chemical formulas.

Finally, Dr. Phelps said that he would welcome another war if it would produce as much literature as has been written about the Trojan war. But the scientist knows that war is not romantic. Maybe the Trojan war was, but he suspects that it is only one of those old unhappy far-off things that become romantic when seen through the haze of centuries. The Trojan war was fought over a woman and no woman is worth fighting over, not if men of good will and intelligence must kill each other or even quarrel.

Well, let us have an end to this literary quibbling. What kind of truth is this truth of great literature that stands impassive and unshaken and, one might add, unaware of the passage of centuries? Well, it is not a truth that will help us in a world that is too much with us whether we like it or not. The world of literature is a dream world on the other side of the looking glass where things are touched up a bit. It is a world of escape from reality. God knows there have been ages when whole populations sought to escape and it may be the time is near at hand when we shall again seek some sort of a cloister or take some kind of a drug to avoid looking at a reality that we can not face, but this can not be regarded as anything but the avoidance of truth.

I have made no mention of the scientific method up to the present time, but of course what I have been trying to do is to apply the scientific method in an analysis of the truths of literature. The scientific method is nothing more than an attempt to determine by careful observation what connection exists, if any, between things that we observe. If one event always follows another, we may say that the first event is the cause and the second, the effect. This is a little naive, says the modern relativistic philosopher, the effect may precede the cause. But we need not worry about that; on the scale in which we observe the events in our world, the cart will stay behind the horse and we may talk about cause and effect as much as we like. But the scientific method is not just common sense. It requires imagination, for example, to unravel the complex life history of a parasite such as the hookworm. No amount of common sense alone would ever arrive at the atom that wave mechanics believes in but refuse to picture; and finally, it requires skepticism and checking against experiments even after a relation seems to be proven. In the use of the scientific method, one must never believe what he would like to believe.

The application of the scientific method to build up a science requires long and patient observations and the cooperation of many observers and the handing down of accumulated knowledge from one generation to another. The scientific method in operation represents the greatest intellectual and social achievement in cooperation that our civilization has yet attained.

Let us take an illustration or two. A farmer once observed that a heavy rain occurred when the new moon looked like a cup partially tipped over in the

sky. He said to himself the water runs out and we have a wet moon. He was observing all right and was using his imagination, but he was generalizing from insufficient data. He had not traced a chain of events leading directly, continuously, and inevitably from the tipped over crescent of the new moon to the rainfall and he had not observed it often enough to eliminate the long arm of coincidence. He was generalizing from insufficient data and the weather bureau still does that day by day for the weather is determined by a situation so complex that defies observation. Another illustration is that of a professor who recently undertook the study of psychic phenomena. The experiment was with a pack of cards. One man turned a pack of cards one at a time looking at each one as he did so. A man in the next room wrote down the name of each card as it was turned. According to report there was too high a percentage of correct answers for pure chance so that undoubtedly here was a demonstration of mental telepathy. Then it occurred to the professor to blindfold the man who turned the cards. The guess of the man in this other room was still too good for chance. Obviously, it wasn't telepathy; it was clairvoyance. I am waiting for a report to the effect that the professor varied the experiment again and found that it was not clairvoyance but metempsychosis. There is nothing like a healthy skepticism in the use of the scientific method.

The scientific method usually requires the use of statistical methods to verify any conclusion and statistical methods never lead to certainty, only probability. I shall never forget that I once took part in a test of certain analytical method or rather, shall we say, a test of the proficiency of an operator of this method The test amounted in fact to making twenty tests to which the answer yes or no must be given. The operator got six right out of 20. But on the basis of pure chance, e. g., flipping a coin, he might with equal probability have gotten 14 right out of 20. In that case we should have had an argument on our hands.

As a result of the use of the scientific method, we obtain rules describing sequences of events which in an expansive mood we call laws of nature. But if we were modest, we should restrict ourselves to saying laws of physics, laws of chemistry, etc. The laws which we observe to hold are only observed to hold in situations which we have carefully simplified. Nature in the raw is too chaotic for us to observe any simple relations with certainty. Jeans, on contemplating some of the remarkable achievements in the way of quantitative prediction in atomic physics, exclaimed that God must be a mathematician But this is very naive conclusion. He might as well have said that God is a biologist because living organisms play what seems to them a very important part in the world. Mathematics is only a kind of language, written in short hand so that our limited brains can follow the complicated relationships. As a matter of fact, the new quantum mechanics has replaced the determination of cause and effect with the statistics of probability and statistics, when applied to a single event, tell us nothing at all. What quantitative measure will tell us is how uncertain is uncertainty?

Of course, it is this sequence of vogues in the view points and terminologies of science that give Dr. Phelps the opportunity for his jibe about buying the latest edition of a scientific book. For example, some one a few years ago said that the physicists were divided into two classes: those who were well satisfied with physics as it was before the advent of wave mechanics and those who believed that the wave mechanics was the last (not the latest) word on the subject. But, of course, we have fads and fashions in art and literature, too. Consider the incoherence of Gertrude Stein and the flux of surrealism.

(Continued in October Issue)

THE SCIENCE TEACHER

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The Illinois Biology Teachers' Association
The Indiana High School Chemistry Teachers' Association
And Serving Other Science Associations

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OUR FRONTISPIECE

The silver loving cups shown on the cover were awarded by the Illinois Junior Academy of Science to high schools for excellence in project, poster, notebook and other work exhibited at its annual meeting in 1938.

INDIANA MEETING

Indiana chemistry teachers are no doubt already planning to attend their annual meeting coming April 14-15 at Muncie, Indiana. Both days are quite promising both as to program and field trip (See page 12 for program).

But aside from the real value of the program it should not be forgotten that there are other important values in meeting together. In such meetings one is stimulated to do better work, to try new ideas, and to get out of a "rut". He can talk over his problems with other teachers and he can form friendships of great value. Surely no teacher should miss a state meeting, especially such an excellent one as has been arranged by Mr. Dilts and the other officers of the Indiana High School Chemistry Teachers Association.

JUNIOR ACADEMY OF SCIENCE

Good fortune is favoring boys and girls interested in science club work and in the activities of the State Junior Academies of Science. A donnor has already arranged to give a large amount of money to promote the work nation wide. Considering the fine work done by these groups its value in the learning process and the intense interest they arouse among students, it appears to be a most worthy cause to support. Previously, the activity program for science students has sorely needed funds. The name of the corporation awarding the funds is not to be made public.

Under the plans being formulated one of the new innovations is that one boy and one girl in the State is awarded membership in the American Association for the Advancement of Science without cost to themselves. Those so honored are chosen by vote of students in clubs affiliated with the State organization. The candidates must have a high scholarship record. Further information about the work in Illinois may be had from Harry Adams of Bloomington High school. Outside the state information can probably be obtained from Science Clubs, Inc., New York City or from Louis Astell, Editor, Science Club Service, 1204 West Nevada street, Urbana, Illinois.

Activities and Science Instruction

A visit to the student exhibit at a State Junior Academy of Science meeting will raise in the mind of any science teacher some important questions. Do the science activities of which we here see evidence help students to learn the principles of science and, if so are such aids to learning desirable?

As to the activities in question, a glance about an exhibit hall may show commercial products, such as mirrors, vanishing cream, radio sets, etc. all made by students; working models of commercial equipment, such as a sulfuric acid plant; and skeletons of animals, mounted for class room use. Then there are note books, posters, and collections of many types.

What is seen at the academy exhibit only indicates a small part of the activity back home at the high school.

For teachers who have had much experience with activities of the type mentioned there is no need to answer the question as to their value. These teachers know the very real value of activity work. But for those without experience in the activity instruction of this type who sincerely desire to make professional progress some answer should be given.

It should, of course, be noted that activities are not a new thing in science teaching. In fact, laboratory work, whether of the individual or of the student demonstration type, is an activity that we have long associated with the best type of science instruction. What teacher who has the advantage of a laboratory has not heard many students say they enjoy the laboratory work more than the class recitation period? The student is faced with concrete problems about materials he can see and touch. He has real first hand physical and mental experience. Interest is stimulated. Memory as well as reasoning is promoted. In fact, many teachers find they do their best teaching in the laboratory while the students are engaged in activities.

The use of individual or group projects is actually an extension of the laboratory type of instruction. The work becomes more individual and consequently more fascinating, more stimulating to the students imagination, and more challenging to his reasoning powers. It is not an accident that in schools where project work is used extensively in science that a large percentage of students elect science. For example, more than eighty per cent of a high school group have been known to elect chemistry even though chemistry was not a required subject. Students are quick to evaluate a course in terms of its relation to their needs and most of them choose their courses accordingly. To them science studied through activities closely related to life is vital. They are willing to take the course even though they know it means work.

The mental attitude of the student is often profoundly changed. Even preconceived dislike for the subject may be replaced by a liking for it. One boy, for example, was changed from a disgruntled individual, for whom school was a bore, to a pal of the chemistry teacher through the simple act of making shoe polish and doing a really good job of shining the teacher's shoes.

But, "Are you teaching the principles of science," some may say who yet believe in the stereotyped college preparatory course for all. The answer is "yes". In fact, those who have had much experience with projects and other activities believe the principles can be better taught through the natural situations they provide. For example, making a sulfuric acid plant, whether by one individual or a group will certainly provide a learning situation, which will require the mastery of the principles of chemistry involved, not alone for the individuals working on it but for the whole class. Likely the project will be remebered long after many other parts of the course have been forgotten.

JOHN C. CHIDDIX, Editor.

Trends in Subject Matter Content in Science

WILLARD L. MUEHL

J. Sterling Morton High School Cicero, Illinois

One of the trends in chemistry today is to place more emphasis upon the consumer's viewpoint. The newer texts are using many more practical applications of the fundamental principals of chemistry than formerly, and our laboratory manuals are also tending in that direction. I believe that a great deal of supplementary material can still be added to our laboratory work and enrich it in such a way that our pupils will find it much more worth while.

By consumer chemistry, I mean the testing and the making of many of the products that our pupils come in contact with in everyday life. In arranging some of these special experiments, the teacher should always keep the special interests of that community in mind and provide those experiments that will be most interesting and helpful. In the past many of our high school chemistry courses were largely a simplified college course, with a teacher who refuses to deviate from the text or laboratory manual for fear that the State requirements would not be met. A large percentage of our pupils that study chemistry in high school will never have a chance later to study its more practical applications, while as consumers their entire life will be greatly influenced by it. While on the other hand, those that continue to study chemistry will find it to their advantage to be able to associate the theories of chemistry with its practical applications. We at Morton feel that experiments of the special interest type open new avenues of thought, new reasoning, as well as developing an unusual interest in the course.

One of the purposes of teaching high school chemistry should be to interest our pupils in such a way in the course that their interest will continue beyond it. Let us suppose that I am teaching chemistry in some rural high school. Don't you suppose I could interest John Jones in my course if I were to make up solutions in the laboratory for him to test samples of soil from his father's farm and determine quantitatively what deficiencies might exist in those samples. I believe also that John's father would think that I was teaching one of the most important courses in that school. To have him feel this way is going to help him and me as a teacher considerably. Or if you could have your pupils test some kind of ice cream, they would begin to wonder why it is called ice cream at all, or why chocolate milk is not called chocolate skimmed milk. There has been too little "selling" of chemistry in most communities, and, perhaps, that is the reason why many of the smaller schools feel that the cost of equipment for the course is more than their pupils would get out of it.

We have all met folks who have expressed themselves about their chemistry course, as having been difficult and uninteresting. Parts of the course might be difficult for some pupils, but it can be made interesting. If the scope of our chemistry course is enlarged and the laboratory manual is supplemented with special interest experiments that meets the needs of the pupils, I believe that we will then be doing a real job. In an attempt to stimulate this sort of interest in our pupils at Morton, (Mr. Porter, Tuleen, Mansen, and myself) have found that by making as many applications of chemistry to the everyday life of the pupil, their interest is increased in about that proportion. The teacher's enthusiasm and interest in chemistry is important to stimulate the pupil to feel that he is taking one of the most practical courses in science. Some of our teachers have expressed themselves, that they did not know who got the greatest "kick" out of the special interest experiments, the teachers or the pupils.

A teacher using this method will soon discover that a rather broad and

varied knowledge of the subject is required, much of which have been omitted from his former college courses. He will find that his pupils can ask about as many questions as a four year old boy, but the pupils will be interested. We find that we get the best results from our pupils when we give them considerable general information about the experiment, either orally, or in mimeographed form. They also have access to about seventy-five special reference books in the laboratory to aid them with further information. The teacher must be the motivating power in this kind of work to keep things going smoothly. We believe that the pupil's interest is aroused because his viewpoint of the subject has been enlarged beyond the text.

To illustrate what we mean, let us cite for example the amateur radio operator who has progressed far beyond the training of his physics teacher, just because he was interested in it. In fact perhaps you with other science teachers that I know seldom delve very deeply in this subject of radio with these amateurs, for fear that you might reveal your ignorance of the subject. No doubt most of you have some of these candid camera addicts in your classes that take pictures of everything on the land, the sea, or in the air. They can talk as glibly of lenses, filters, films, quick stops, and developers as if they had just graduated from a school of photography. My contention is that we try to develop that same enthusiasm in different phases of chemistry. Most of us realize that there are not many Charles Hall's or Carver's in our classes, but each year at the Junior Academy of Science meeting, I marvel at the remarkable pieces of work that some high school pupils turn out through just a little attention from their instructor.

The experiments that we are discussing are not meant to replace the regular manual but only to supplement it. This consumer's chemistry can be roughly classified into two groups:

1. Special types of analysis and tests of common commercial products.

2. Instruction in the preparation of products that are commonly used.

For example in the first group, we have our pupils test the vinegar, the ammonia, the milk, and the water softeners that they use in their homes; the antifreezes, the gasoline, and the lubricating oils that they use in their cars; the cold creams that they use on their faces; the ink that they use in their fountain pen; or the soil that they have in their garden or lawns.

In the second group of experiments, we supply the pupils with tried formulas that compare favorably with the commercial products, and they prepare small quantities of them for their own use. We supply them with the equipment necessary in the laboratory as well as the ingredients use, and they pay for the cost of the materials from their breakage cards. If they wish, they may prepare tooth powder as well as face powder, cold creams, cleansing creams, hand lotions, lipstick, or shaving creams, either brush or the brushless variety; fountain pen ink, or floor waxes. We use this latter method of teaching because we find that the analysis is too difficult or even impossible in some cases, so they learn about the materials that they contain by actually making them.

And might I add, that as soon as the pupil wishes to prepare larger quantities of these materials for his own use, we ask him to purchase the ingredients from the local merchant, druggist, or wholesaler.

You might disagree with the educational policies of Henry Ford, but I am going to quote from an article appearing in The Forum that might have some bearing in this method of teaching chemistry. "As a matter of fact, it isn't really necessary to teach children. All you need to do is to let them learn. We adults would find life much pleasanter if we went about as a child does—always wanting to learn, always sharing what we've learned, never satisfied with what we know, always wondering what we don't know . . ." We aim to restore the

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Progressive Education and Science Teaching

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I believe it is unfortunate indeed, especially at this particular time, that the term **progressive** should take on the meaning of the term radical in the minds of some educators. It is true that much printed material, even of so called progressive education, would lead one to believe that their practices are radical and while they may be applicable to some situations, they are of no practical value to public schools as a whole.

I do not look upon the Progressive Education Association and its experiments in this light. Progressive education means to me experimental education, and it is fortunate for all of us, whether we know it or not, that we have such an able and energetic group carrying on research work in educational practice. An inside look at the personnel of the association will reveal public and private school teachers, administrators, and instructors serving as staff meubers of the progressive education association, who are sound thinking men and women vitally interested in educational problems of today and of the future. Many of them are much more conservative in their thinking than most of us would think. The Progressive Education Association is a small group, when compared to such an organization as the N. E. A. The association feels that one of its reasons for existing is for experimental work, work of a nature not sponsored by other educational associations.

My comments in this paper will be confined to science training for a general education. I do not feel that I know all the answers to the questions of present day science problems; in fact I know very few. I do not propose to defend progressive education practices for science in general education, nor do I propose to condemn them. I do feel that traditional science practices in general education are already on the defensive. Any criticism of well planned experimental practices by the traditionalists is bordering on the idea of searching for obstacles to oppose progressiveness rather than examining it and salvaging what may be sound and adaptable to our situations, in order that we teachers may do the job of science teaching better. The attitude of open mindedness will be of benefit in solving our problems.

Let us consider for the moment what may be the science training of a boy or girl from elementary school through grade twelve. The child entering grade one and continuing through six will receive many introductions to science. In the junior high school he may or may not have a course in general science. This course may be for one school year or be spread over three years. In high school he may be required to take one year of science to graduate, and often his choice is limited to one of the departmentalized sciences such as physics or chemistry. This seems to be a very meager science program, and can give only a rather narrow science training. It is true, some schools have a more complete program, but I do know of some small schools that do not offer as much. I have in my own classes students who have had no science in junior high and conclude their science training by taking one year of a specialized science in high school. Needless to say this student receives a very narrow and meager science education. The value of science today in the personal, social, and econmic lives of individuals should by all means make science as important in the general education of boys and girls as social studies, English, etc. A program calling for some science in all grades of the elementary curriculum, a three year general science program for junior high school, biology for the 10th year, and physical science for the 11th year, with elective specialized sciences for the 12th

(1) "Science in General Education," D. Appleton-Century Company, Report of the Thayer Commission of the Progressive Education Association.

year, does not seem too much for general education.

Whatever the science program for a school system may be, the purpose of science in general education cannot be considered without having in mind the purpose of general education as a whole. To state the purpose of general education is analogous to stating the objectives of general education. The same is true for science in general education. The objectives of science in general education should be in harmony with objectives for general education. One may ask, do science teachers have objectives for the teaching of sciesce?

The study of Wilbur L. Beauchamp, "Instruction in Science"[1] revealed a mixture of objectives and practices of the period from 1880 to 1910, which stressed largely mental discipline, and from 1910 to 1930, which stressed the importance of pure applied science.

(1) Instruction in Science, Bulletin of the United States Bureau of Education. Monograph No. 22, p.

The objectives of science as taken from this report show little agreement about what science is to accomplish. Such objectives as, "to develop the ability to think scientifically," "to acquire a knowledge which will produce a better understanding of our environment." "to acquire a knowledge of fundamental principles of the subject" are frequently chosen as objectives by science teachers. A study of the conduct of the courses and the content employed reveals an evident emphasis on covering ground with a disregard of giving the student a need for orientation in his immediate environment.

A change in the psychological theory has tended to cross up old objectives and present day practices. Modern psychological theory emphasises that learning is placed on the total situation. The individual needs to have more inclusive wholes for bringing together the elements with which to interpret the situation at hand. The individual operates and responds as a whole, and yet we separate all of his education, science education included, into small parts and hope to turn out students from this general education who respond as a whole.

The readjustment into new practices requires much thinking, planning, and work that teachers and administrators would perhaps rather avoid. We are all trained by the old methods and too many of us are not science teachers at all. We are chemistry teachers, physics teachers, biology teachers etc., and see the problems from our own specialized field. We do not see the science field functioning within the individual as a whole, as Eckels, Shaver, and Howard say in the text "Our Physical World," "science is not chemistry one day and physics the next," but rather operates as a whole.

The youth must see relationships between his environments, both physical and biological, and other areas of living in order to understand fully the basic aspects of living. This understanding falls directly as a responsibility of science teaching. The report of the science committee, "Science in General Education" of the Progressive Education Association has thought of the basic aspects of living in terms of four categories, viz: (1) Personal Living; (2) Immediate Personal-Social Relationship; (3) Social-Civic Relationships; (4) Economic Relationships. It is possible that other categories involving the same problems might well be given, as human relationships are not always sharply defined into definite categories.[1] These categories form the basis from which the objectives of education in a democracy and science in that type of education are formulated.

The science program should strive to meet the **needs** of boys and girls. The term **needs** is not to be interpreted here as meaning an immediate desire, nor, the demands of society on the individual, but rather it should carry with it a concept that is "personal-social in character". Needs of this nature arise only from "interactions between the individual and the social situations". Any list of needs would then be mere classification of personal-social situations.

Democracy depends for its existence on the intelligence of common men.

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Suggestions for Biology Field Trip

V. G. CATLIN

Proviso Township High School Maywood, Illinois

We recognize that experience and observation are prime factors in the educative process when properly controlled. The value of observing first hand the factors actually at work determining the amount and kind of life in any area cannot be better obtained than in the field. Studying material in the laboratory that has been gathered by some one else falls far short of producing the desired complete understanding which should be built up in the minds of the students. That comes only through total associations. Life functions and procesesses can only be adequately understood when the pupil forms correct concepts through representative groups actually engaged in the business of living in a natural habitat. In order to truly learn of life one must study it in the act of living in God's great out-of-doors.

In making such a statement I do not wish to lessen our appreciation of certain types of indoor work. Certainly organ and body structure may be studied better in the laboratory than elsewhere. Text book work is necessary but text book biology alone is almost useless, unless one wishes to merely put in his time. The text and laboratory are not sufficient to produce adequate understanding of the living world. If to these we add field study, biology becomes meaningful and very interesting. Much, however, depends upon leadership.

A few years ago a ship, the Morro Castle, which you no doubt remember reading about at the time, was moving up the Atlantic coast with a load of picnickers, homeward bound. In the cabin the captain lay dead, having died an hour before from acute indigestion. To this disaster was added another, the ship caught on fire. Within a few minutes the passengers and crew were in panic. They jumped into the ocean without life preservers, life boats were upset in the act of lowering, and hundreds of people were burned to death. Truly, all was chaos, the result of being without a leader—especially one with courage and possessing judgment tempered by experience to lead and direct a group totally lacking in these essentials. The control of conduct is always an important factor in human affairs.

Not long ago I was riding along the country highway, with hardly a care in the world, on my way fishing, when upon meeting an approaching car, a young lady leaned out of the car window and shouted to me as she passed, "flat tire". My whole attitude changed at once. I stopped my car as soon as possible, jumped out and hurried around the car to see which tire was going down. I believed that I had a flat tire. My actions were determined by that belief. Actions are always influenced by those things we believe to be true. This is equally true of the pupil and teacher. Our actions are largely determined by our previous training. If we are to train the pupil correctly we must be well prepared both in a general way and for each day's work. We must believe in that which we seek to do. We must know the purpose and place of each phase of the work that we give our students to do, and realize when the purpose has been accomplished. We must know what is to be gained in the field ahead of time and take the class to the place where this can best be attained. The field is not a place to send the pupils nor a place to show them the sights as though we were tourist guides, but rather a place for the teacher and class to study and enjoy their work together. I doubt that pupils should ever be sent. The best results come through leadership and not through "sendership". If leadership is not needed then I fail to see the need for the so-called teacher. I believe the good teacher will work with the class and not have the class work for him.

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Bacteriology in the High School

F. W. TANNER

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(Continued from February issue)

Such products as insulin, bacterin, antitoxins and many drugs would be unknown today without experiments with animals. While voters have refused to make animal experimentation illegal, those who wish to do so will continue to expend every effort to accomplish their goal. We must be constantly on guard to prevent enactment of laws which would not only inhibit much work in biology but which could not help but inhibit progress in conservation of human life.

Complementary to the role which bacteria play in pathogenic bacteriology is that in the industries. Few laymen appreciate their importance in this respect for it is more generally believed that their main role is in disease. Several examples of the use of bacteria in the industries may now be mentioned.

During the World War Germany became destitute of fats for human consumption. What fat was available was incorporated in sausage and sent to the German soldiers in the trenches. The civilian population suffered greatly and had to attempt to develop new sources. Experiments finally indicated that fat could be made by a microorganism, **Endomyces vernalis** in the cells of which about 30 per cent of fat appeared. On account of its strong odor and taste, it was not welcomed by the German people.

Another interesting application along these same lines was the production of gycerol by fermentation in Germany for use in making explosives. This compound in times of peace is produced in sufficiently large amounts as a by-product of the soap industry. During times of military emergency, however, the supply is rapidly depleted and some new source must be found. Exhaustion of the supply in Germany was a serious problem which was finally solved by fermentation. Glycerol was made by growing yeast in an alkaline sugar solution which yielded glycerol instead of alcohol the usual product. Great Britian was making some one million kilos of glycerol a month in this manner when the armistice was signed. Microorganisms are being used today in America, also, for making butanol and acetone. Hydrolyzed corn starch is fermented by pure cultures of a species of bacterium.

While some bacteriological information may be given in the biological course, the subject is too specialized and expensive to teach in a separate course to justify extended treatment. Owing to the special apparatus and materials required, the students probably cannot carry out much bacteriological technic themselves. Such instruments as high pressure steam sterilizers are required for sterilization of culture media and glassware, and petri dishes and pipettes. Also, only those who have had some instruction in the science, will appreciate just what has to be done. Every high school biology laboratory could afford a few petri dishes, pipettes, and when needed, a few tubes of agar media. The latter may be purchased from supply houses or from a hospital laboratory. Unless the teacher has the training, these may not be used in the right way. Absolute sterility of apparatus and media must be accomplished and sufficient control cultures made to bring out the lessons which are to be taught. After growth has been secured in or on culture media, films may be prepared for staining in order that shapes and sizes of cells may be observed.

Despite these difficulties some laboratory work may be done. Steam pressure cookers may be used for sterilizing apparatus and media. Hot air ovens of kitchen stoves may be used for sterilizing dry glass apparatus wrapped in paper.

One of the most difficult problems with new students of the science is to have them appreciate the wide distribution of bacteria and their small size. Var-

PROGRAM

Indiana High School Chemistry Teachers Association

Ball State Teachers' College, Muncie, Indiana

April 14-15, 1939

Friday, April 14

10:00 a. m.—2:00 p. m. Registration, Science Hall.

2:00 p. m. Program.

Chairman: Charles D. Dilts, High School, Ft. Wayne, Indiana.

"The Aid of Science in Criminal Investigation," Captain John T. Taylor.

"Possibilities of Visual Education," a discussion led by Mr. Druley Parker, Shortridge High School, Indianapolis, Indiana. Showing of new films.

Business Meeting.

6:00 p. m. Dinner.

Address by Dr. Frank Graham, Ball State Teachers' College.

Address by Dr. Ernest A. Wildman, Earlham College.

Topic: "Acids and Bases".

Saturday, April 15

9:00 a. m. Story of Ball Brothers Glass Jar Plant.

Trip through the factory.

NOTE: Send in your dues of $1.00 to Miss Leda Mae Hughes, Shortridge High school, Indianapolis, Indiana. As a member you receive without further cost The Science Teacher, the official publication of the Association.

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ious means may be used to accomplish it. When this is done, the student is oriented in that section of the evolutionary lines of living organisms where his attention is being focused. While he may see bacteria under the microscope, his attention should be called to another world of organisms, much smaller. These cannot be seen at all and are known mostly by what they do.

Much fine literature is now available on microorganisms for students at the high-school level. That published by the Metropolitan Life Insurance Co. is especially noteworthy. Their "Health Heroes" series of little biographies of Edward Jenner, Robert Koch, Florence Nightingale, Louis Pasteur and Walter Reed and "Health Through the Ages" should capture the interest of any high school student of general science or biology. Among others, the following may also be mentioned for teachers "Biographical and Scientific Material in Health Teaching;" "Health Through the Ages;" "A Practical School Health Program;" and "The Nature of Bacteria. The names of a few books which might interest high schools are given at the end of this article.

To sum up this discussion, bacteriology does not have a place in the biology curriculum of the high school as a separate course. A few demonstrations to show the small size of bacteria, their ubiquity on the hands, in water and other foods, and methods of cultivation may be given. These, however, should be a part of the survey course which is today called general biology. The biology teacher can easily devise experiments which will emphasize the significance of bacteria on the hands and various fomites such as the common drinking cup and used table ware.

REFERENCES

Andress and Brown. Sciences and the Way to Health;" Ginn and Co., Boston, 1929 (Written for Junior High School)—Chapters III, IV, V, VIII.

Andress and Brown. "Experiments in Health". Ginn and Company, Boston, 1929. (Written for Junior High School).

Conn. "Bacteria, Yeasts, and Molds in the Home". Ginn and Co., Boston, 1917. (Written for adults)—Section III, also appendix pages 280-287.

Chemistry and Biology in Medical Training

JAMES H. BRAYTON

Manual Training High School Indianapolis, Indiana

(Continued from February issue)

Pasteur first showed that racemic acid was really a mixture of two types of crystals, one the image of the other, and that when mechanically separated and dissolved in water, the one type turned it to the left, suggesting at once that the racemic acid was really a mixture of the d- and l- tartaric. Van't Hoff, the Dutch chemist, continued this work and developed the theory that Avargado's hypothesis applied to non-electrolytes in solution.

Saccharin was first produced by Ira Remsen, professor of chemistry and later president of John Hopkins University.

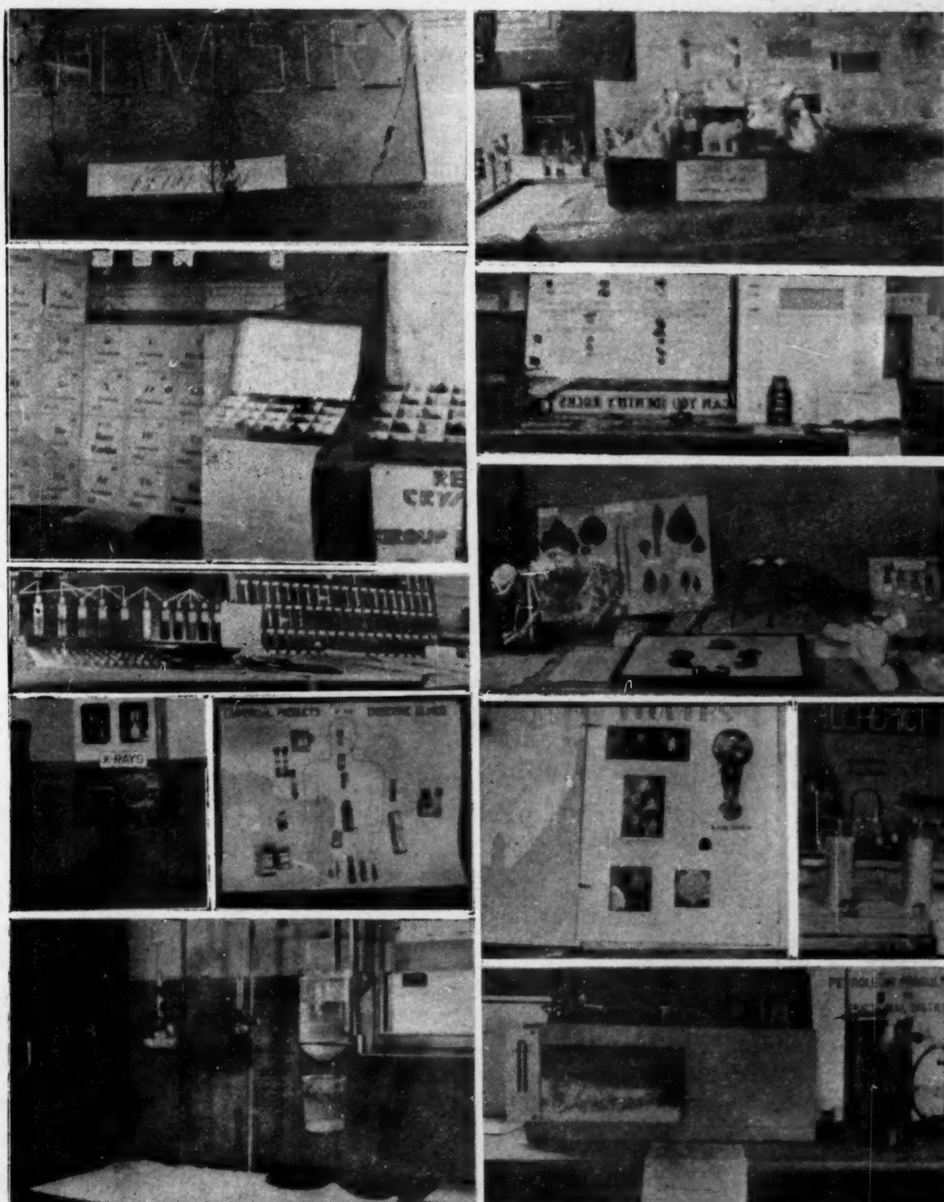
Meanwhile in Europe the following events were taking place. Faraday had separated from fish oil a stuff called benzene. KeKule in Germany later in 1865 devised the ring formula for this. Pasteur in France was conducting investigations which started bacteriology and was not idle in the field of chemistry, for it was Pasteur who, noting that tataric acid and its isomer turned polarized light in opposite directions, established the principles of stereochemistry. Koch was establishing the science of imunology. Ehrlich, the father of Chemotherapy, was beginning his work on microscopic stains and dyes, and was testing for bile pigments with sulfanilic acid, ($NH_2C_6H_4SO_3H$). (This acid is the mother substance, of sulfanilamide, selected by some as the most important medicine of the year 1937, because of the discovery of its apparent efficiency against internal diseases caused by streptococci.)

The term 606 means that this was the 606th combination of arsenic with other chemicals which Ehrlich made in his attempt to find a substance which would kill most of the germs and not the patient. When Ehrlich first began his celebrated research he was aware of the fact that trypanosomes are killed by a number of dyes and a number of organic arsenic compounds, of which "atoxyl" was the most important. This compound contains pentavalent arsenic. The important discovery was made that although it would cure animals, it had no toxic action upon trypanosomes themselves. After many trials with many arsenical compounds, Ehrlich was in a position to formulate this general rule: that only compounds containing trivalent arsenic were effective in killing trypanosomes, and that the effectiveness of compounds containing arsenic depended upon their reduction in the body to the trivalent form. The most efficient substances were found to be compounds containing trivalent arsenic joined to a benzine ring and containing an amino group. Salvarsan is a dry yellow powder, and an irritant acid. It is therefore mixed with sodium hydroxide which makes it a salt. It is injected into the vein without air. In their offices most doctors give neo-salvarsan which is less difficult to mix but less effective. It was the 914th discovery of Ehrlich. Bismuth, mercury and potassium iodide are also used.

Medical education in Indiana has had the advantage of supervision by several agencies, national in their scope. The medical education situation has had continuous study and support from the General Education Board and Rockfeller Foundation. The vast work of the Rockfeller Foundation in all parts of the world arouses the frequent admiration and enthusiasm of medical editors throughout the United States. The Council of Medical Education of the American Medical Association keeps a watch on medical schools and standards of medical education. Their latest improvement has been the proposal to require doctors who in the future wish to specialize, beginning 1940 or 42, to be divided into 12 groups, to interne three years in their speciality and spend two more years in its study and practice. The result has been a great advance in the

(Continued on page 23)

Exhibit of Illinois Junior Academy of Science



The work shown above was selected at random from among the many entries at the 1938 exhibit of the Illinois Junior Academy of Science at Carbondale, Illinois. The exhibit was judged and awards made to 1st, 2nd, and 3rd place winners in each of the sciences. Loving cups (see front cover) went to schools having the highest number of points in a division.

The 1939 meeting and exhibit is to be held at Springfield, May 5. Entry blanks may be secured from Miss Audry Hill, Chester High School, Chester, Ill.

TRENDS IN SUBJECT MATTER

(Continued from page 7)

vital connection between knowing things and doing them".

Briefly I shall attempt to suggest a few experiments that we find interesting to our pupils. Early in the course after we have discussed simple mixtures, we explain something about some of the mixtures that they use that are of commercial value, namely tooth powders as well as face powders. These are some of the things that they have wanted to know something about, and they immediately feel that here is a course that is practical. After they answer a series of questions prepared for them and demonstrate that they know something about the ingredients that these products contain as well as the purposes that they serve, we have them prepare samples for their own use. And after they have had a chance to use them, they are very favorably surprised, that some product that they have made really works.

Later on in the course after the pupils have studied acids and bases, we teach them how to titrate and test solutions of this type that they come in contact with daily. The chemistry instructor prepares the standardized solution for the pupils use, and it is surprising the remarkably accurate results they get in testing household ammonia and vinegars. Often a dozen different varieties are purchased locally, priced and then tested by the pupils to determine the most economical variety to buy. Bleaching solutions are often tested in a similar fashion a little later in the course.

The analysis of milk, chocolate milk, and ice cream are carried on during the study of the characteristics of sulphuric acid. The analysis consists of the quantitative tests for butter fat, acidity, and the specific gravity of the milk. Analyses of this type are prepared by the instructor in mimeograph or ditto

form, so that the pupils perform the experiment with very little additional explanation from the instructor.

The study of emulsions becomes much more real to the pupils if they are able to make any one of a half dozen different kinds of cold or cleansing creams for their own use at perhaps one tenth the usual cost. Much of the mysterious and the magical qualities of the advertised creams that they use soon disappear into thin air.

During the discussion of sodium and potassium compounds, our pupils make qualitative analysis of many different brands of water softner. They report in their results whether the softner contained a phosophate, a borate, a silicate, a carbonate, or a combination of any two of them. Our pupils soon discover that it is much more economical to purchase water softener under such names as borax, tri-sodium phosphate, or washing soda, rather than in a brightly colored box. This experiment is then followed by one to show which one of the four compounds is the most effective softener of hard water.

Our pupils learn something about the art of soap making when they prepare a shaving cream that compares very favorably in quality with the commercial varieties that you purchase. The cost to the pupil is approximately twelve cents for the one half pint that he prepares.

The preparation of ink has a very definite consumer's value at Morton, because all of the blue-black ink used in the school is prepared in the chemistry laboratory.

We have perhaps made a rather meager attempt in our discussion of one of the trends in the subject matter content of chemistry today, but we hope that perhaps a few of our suggestions will help you to see that we try to teach our students consumer chemistry. "We aim to restore the vital connection between knowing things and doing them".

PROGRESSIVE EDUCATION

(Continued from page 9)

There is then a need for free play of intelligence in criticism and evaluation.

The student finds such needs as "personal health, self assurance, range of personal interests, aesthetic satisfactions, and a workable philosophy for life" in his own "personal" aspects of living. Such personal characteristics as tolerance, cooperativeness, creativeness, self direction, social sensitivity, and reflective thinking are essentials to the individual in this aspect of living.

In the "personal social" aspects of living, the adolescent as he grows older, finds need for more mature relationships in the home, with adults outside the home and age mates of both sexes.

In "social-civic" aspects of living the individual finds increasing needs to participate in significant social and civic activities and to gain some social recognition.

In the "economic" aspects of living the student finds needs for guidance in choosing an occupation and preparing for it, for the wise selection and use of goods and services, for an assurance of progress toward adult status, and some effective action in solving basic economic problems.

Other needs for students may be added to this list. Needs cannot be stated once and for all, nor can they be exactly the same for all students in the same school.

A need that looms large in this list is the need for reflective thinking. All science teachers hope to instill this ability and the use of the scientific method into their students, but honestly speaking, from our present science teaching practices, are we not failing to give this need the necessary attention.? In short, our students fail to achieve this objective, because of our eagerness to cover a specified amount of content whose sequence does not always lend itself to, nor give opportunity for reflective thinking.

It does not seem logical to discuss the encouragement of reflective thinking without paying attention to the improvement of reflective thinking through improvement in the use and understanding of language. It is believed that this has the support of psychologists and others who have studied the relation of language to thought, and that reflective thinking is increased by the ability to express oneself clearly in words and to recognize confusion in the discourse of others.

This advocated reflective thinking together with the other objectives of science are not adequate tests in themselves of the efficiency of this new science study, but rather the conduct of the student in real life is the test. A sampling of student response by the usual method of testing is no basis for evaluation. To devise an evaluation program which gets information concerning student progress toward all objectives of general education is a very complex task and cannot be accomplished by the usual practice of written tests.

The science committee of the Progressive Education Association believes that evaluation of student growth in such a characteristic as reflective thinking should involve methods of measuring his (1) ability to discover and define problems; (2) ability to observe phenomena accurately; (3) ability to select facts relevant to a problem; (4) ability to collect and organize facts; (5) ability to draw inferences from facts; (6) ability to plan experiments and to test hypotheses; (7) ability to apply facts and principles to new situations; and (8) scientific attitudes. To get as complete a picture of the student as possible, it seems necessary to make use of all available records, trained observers, questionnairs, interviews, and construction of new instruments of evaluation.

Neither space nor time permits me to discuss the wory of the science committee of the Progressive Education Association on the evaluation of student achievement. The committee under the able leadership of Dr. Tyler has done much work on evaluation that is available for inspection. And that should be in the hands of every science teacher.

(1) Science in General Education, Report of the Committee on the Function of Science in General Education (D. Appleton-Century Co., 1938), p. 27.

BIOLOGY FIELD TRIP

(Continued from page 10)

Carefully thought out procedure and policies point to success in field work, while attempting to work with poorly thought out plans, or going to the field without any, lead to waste of time by part or all of the pupils and lessening of respect for the teacher and for the course. Careless teachers make the pupils careless.

The following suggestions are offered as aids, especially to young teachers or to those who may wish to improve their work in the field. They are given with the hope that you may develop the best there is in field trip work. I offer them after many years experience in teaching high school biology in communities of various sizes. During this time I have come to realize the very great value that may be gained from well conducted field trips.

1. Take them often and conduct them in as matter of fact manner as you would any other phase of biology work. Apologies are never necessary when work is well done.
2. They must "fit in" the right place.
3. They must be a very definite part of the course.
4. They must serve a very specific purpose.
5. The teacher must take the class to the right place.
6. Let the class think they are making the discovery.
7. The class must have a very definite problem before going to the field.
8. Field trips should throw light on "big problems" as well as upon minor ones.
9. Students should generally take notes in a scratch note book for later use.
10. The material should be organized upon returning to the science room.
11. Conclusions should be brought out at the proper times.
12. Nearly all trips should require some written work.

13. Written work should be carefully planned by the teacher in advance.

14. Appropriate tests should be planned to be given in the field from time to time. These should be given to "show up" the degree of achievement attained by each member of the class.

15. Take field trips for two reasons: to work on a definite problem and to have a good time. The class should leave the building quietly and orderly and return in the same way, but once outside let them laugh, talk, sing or whistle. The teacher must lead the class, however, not follow them. He must insist upon silence when he wishes their attention. In order to avoid delay, keep the class within a few steps distance. In case of bird-study trips, greater precaution regarding noise upon approaching the study must be taken. A teacher who is friendly, but serious, will accomplish most and have the least difficulty.

There are some things that should be avoided as they produce undesirable reactions. They generally point toward failure and are quite definitely characteristics of negative leadership. They are associated with inexperience or indifference. Avoid them!

1. Do not go field trips because the pupils think it is a nice day.
2. Do not go because you have nothing else to do.
3. Do not place pleasure first and work second.
4. Do not attempt too much on a trip. Avoid hurrying.
5. Do not waste time on trips.
6. Do not let the class scatter out unless a captain is appointed by the teacher ahead of time has prepared these captains for their task of leading small groups to pre-determined places for specific work. In such cases, reports should be made by pupils and captains.
7. Do not let the pupils "lead" you.
8. Do not nag the class for one or two pupils' failure.

PHOSPHORESCENCE AND FLUORESCENCE

Who has not at some time been fascinated by the luminous dial of watch or clock that glows in the dark, and has even speculated on what he could do with some of the luminous material both in a practical way and in the way of pure amusement. Consider the use of luminous paint about a key hole or on the light switch, or the possibilities of faking ghosts or having a real halo about ones head in the dark.

If we care to investigate the phenomema from the standpoint of science, we find both phosphorescence and fluorescence, individual phases of photoluminescence, are a fascinating study. For some inexplicable reason, certain substances are able to absorb and reradiate the energy of light or other radiations such as X-rays, ultraviolet radiations, etc., this re-radiation being manifested in a luminosity of various colors depending upon the substance. Where the luminosity persists for a period after removal of the exciting radiation it is called "phosphorescence". When the luminosity vanishes as soon as the exciting radiation is removed it is called "flourescence". In this latter manifestation the short invisible ultraviolet rays (Black Light) are transformed by the floresing substance into visible light. Fluorescence and phosphorescence always occur at wave lengths longer than those that excite the substance.

Perhaps fluorescence and phosphorescence are one and the same thing. It may be that all fluorescent substances are also phosphorescent, but perhaps the human eye is unable to detect the phosphorescence because of its short duration or because the rays fall outside the spectrum visible to the eye. This possibility has not been fully investigated as yet and offers interesting possibilities to the research student. Decidedly interesting experiments also can be made with certain fluorescent materials showing that they change the refrangibility of light.

Some phosphorescent zinc sulphides possess these two properties to a very high degree and may even be thermoulminescent, that is they become luminescent upon heating. Phosphorescent zinc sulphides may be had that phosphoresce and floresce green, yellow, orange, red and blue and one phosphorescent calcium sulphide shows violet. Innumerable experiments may be performed with these materials. If the green is exposed to daylight or artificial light for only one second it will glow in the dark for hours, which process may be repeated almost indefinitely. The green is also the most sensitive of all known materials to radium radiations. If brought in colse proximity to a radioactive material in a darkened room, distinct flashes of light may be observed through a magnifying glass. This property can be illustrated by using even as small a quantity as one microgram of radium. Some yellow phosphorescent zinc sulphide is also triboluminescent, that is, it luminesces very brilliantly by friction. A beautiful display can be made by putting a small quantity on the stopper of a glass-stoppered bottle and then turning the stopper in the bottle.

The luminosity produced by these materials in exceptionally beautiful and vivid. While the blue has only a very short phosphorescence, its fluorescence under ultraviolet radiation is very intense. Most phosphorescent zinc sulphides show an intense fluorescence under the cathode ray also, the blue having the shortest time lag or phosphorescence and therefore being most suitable for television screen experiments.

The fluorescence of all these materials can be demonstrated interestingly with a fluorescence lamp or an argon lamp, or with any ordinary source of light using a special colored glass filter.

Commercially these materials are used for theatrical displays, exits, danger signals, signs and various advertising purpose. The green is also as the base in the manufacture of radium paint.

A great many organic substances are fluorescent to a certain degree, each having a characteristic color of fluorescence. This property makes it possible

to identify such materials and is useful in the detection of forgeries and alterations in documents, deciphering old papers, testing the authenticity of old masters, etc. Adulterations in foods, drugs and textiles can usually be discovered by the difference in fluorescence. While the commercial application of fluorescence is comparatively new, its possibilities are almost unlimited, and the research student will find it as fascinating subject to pursue. The high school student will also find the study of phosphorescent materials quite interesting, and it will appeal to him as possible project material.

MEDICAL TRAINING

(Continued from page 14)

quality of medical instruction and a happy reduction in the number of schools. In 1910 there were 155 medical schools in the United States and Canada and now there are 88.

If the field of practice for the physician has narrowed it has become more intense. The old time diagnostrician used methods entirely unlike those of the graduates of one of our modern medical schools. In former days the faimly physician approached the patient with an inquiry as to the nature of his trouble and the chances of its being hereditary. He asked him if he had recently been eating anything unusual, if he had been unduly worried, or if he had been exposed to cases of communicable disease. Then thrusting a thermometer into his mouth at the same time grasping his wrist, he took out his watch and counted his pulse. He looked at the tongue and tappped the knee for reflex action, He examined the skin, thumped the surface of the patient to learn the condition of the parts underneath by the sound or sensation imparted to his fingers. From his experience and reading he had a definite idea of the reactions which each disease ought to give to these pro-

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BOOK SHELF

SCIENCE PROBLEMS, Book Three, by Wilbur L. Beauchamp, John C. Mayfield, and Joe Young West. 720 pages—size 8 1-4"x5 1-2". 500 pictures. Summer, 1939. Scott, Foresman and Company. Last book of the junior-high school series of the **Basic Studies in Science Program.**

Like Books One and Two, Book Three (Grade Nine) of the SCIENCE PROBLEMS Series, shows plainly that the authors have approached junior-high school science from the lower grades upwards—rather than "from high school down". These are science books which concentrate on **basic science principles involved in the understanding of large environmental questions.** The Unit-Problem organization of the books has been carefully planned with the objective of leading the pupil up to major environmental problems through an orderly, cumulative approach, rather than introducing him to an unwieldy, over-complex environmental unit all at once. This is brought about by preceding a broad environmental unit with narower units —designed to present, develop, and make functional the fundamental science understaondings involved in the solution of the larger environmental problems.

This integration which insures adequate preparation for solving each problem with which the student is confronted, not only applies from **unit to unit in each book,** but from **book to book in the Series.** In Unit 11 of Book Three—"What Has Been the History of the Earth and Its Inhabitants?"—for instance, the pupil gets a first glimpse into the subject of geology. But in both preceding books he has been preparing for this development. In Units 4 and 5 of Book One—"How Do Heating and Cooling Change Materials?" and "How Can One Kind of Substance Change Into Another Kind?"—he was introduced to the basic principles of contraction, expansion, and chemical change. In Unit 3 of Book Two, "What Causes the Earth's Surface to Change?" was studied. **New ideas,** also, are intorduced in Book Three—and developed to the extent that the pupil really understands them and can apply them; for instance, we find units dealing with the nature of sound and of light energy, and classification of living things.

SCIENCE PROBLEM, Book Three (like the other two books) uses large print on larger pages, many understandable teaching pictures, and informal, readable style to make its message clearer. Helpful Introductory Exercises, real scientific experiments, **self-testing exercises,** and special problems to solve, which appear at the end of each problem, give the pupil a chance to do reflective thinking, develop new science understandings, and apply previous knowledge and recently acquired information in new situations. A **glossary of science words** and a **list of selected readings in science,** suitable for the Junior high, are provided at the back of the book.

MEDICAL TRAINING

(Continued from page 23

cedures, and if the case was not unusual he was ready to name the difficulty.

The modern idea of a diagnosis is a complete survey of the physical conditions probably in a hospital. The appliance for this purpose are of a surprising number; first there is the microscope which has been known for many years, but its application to the detection of disease is now much more general. The blood analysis, preparation of slides, use of the electro-cardiograph, use of the X-ray, many kinds of chemical analysis are possible. The laryngeal mirror may be used by the throat specialist. The roentgenologist may discover defects in the abdominal cavity, in the teeth, in all parts of the body, even in the brain. For highly buffered body solutions the pH may be ascertained by use of quinhydrone electrometric apparatus.

Enough has been said to show that there is little chance for the physician untrained in chemistry and biology, and the trend is toward a more extended use of these sciences in the medical field.